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(54) **METHOD AND APPARATUS FOR USER EQUIPMENT DIRECTED RADIO RESOURCE CONTROL IN A UMTS NETWORK**

(71) Applicant: **BlackBerry Limited**, Waterloo (CA)

(72) Inventors: **Muhammad Khaledul Islam**, Kanata (CA); **Jeffrey William Wirtanen**, Kanata (CA)

(73) Assignee: **BlackBerry Limited**, Waterloo (CA)

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CPC H04W 76/28; H04W 76/27; H04W 16/10; H04W 52/0219; H04W 74/00; H04W 76/38; H04W 80/06; H04W 84/042

USPC 455/509, 516, 574

See application file for complete search history.

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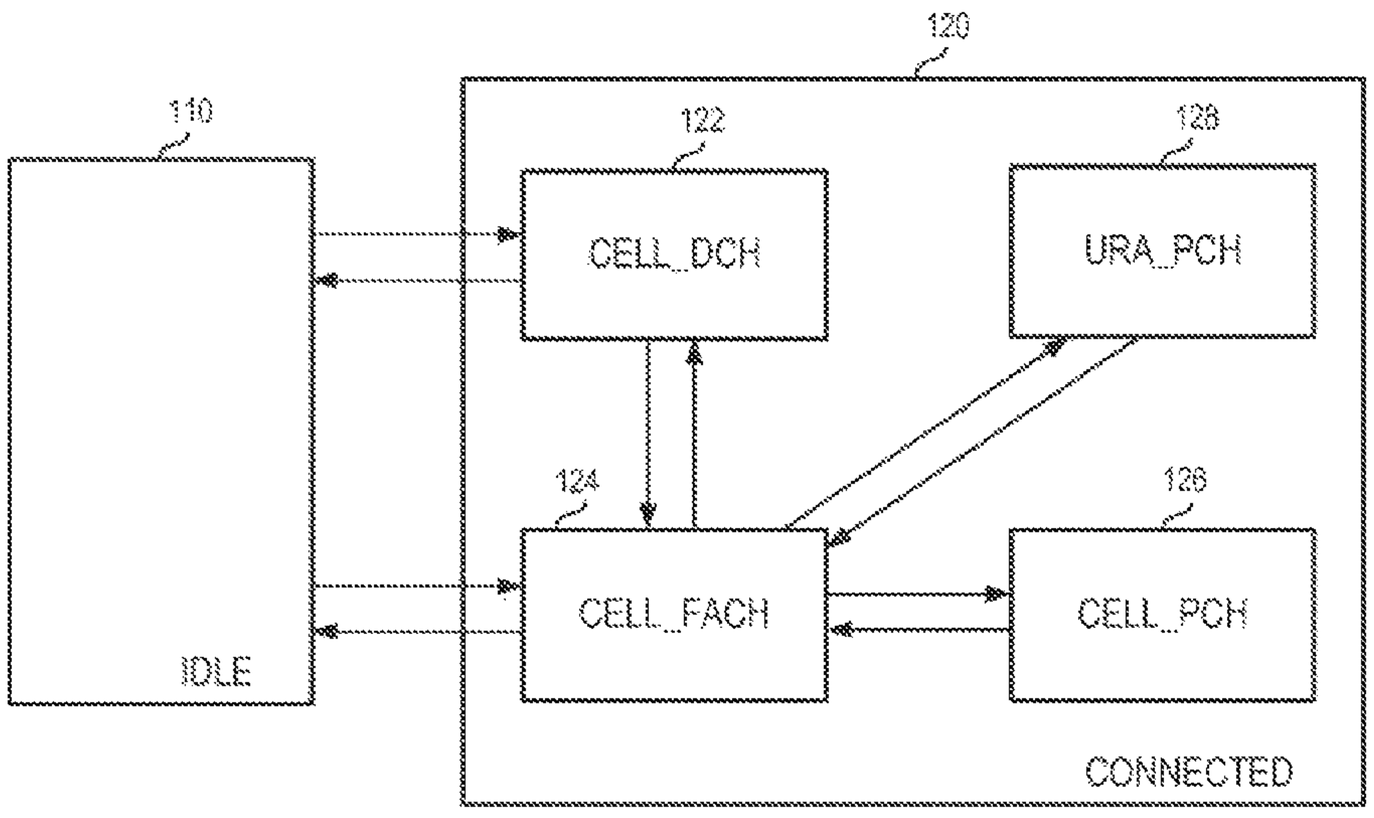
Primary Examiner — Tu X Nguyen

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

A method and apparatus for improved battery performance of user equipment in a wireless network having multiple radio resource control (RRC) states, the method comprising the steps of: monitoring, at the user equipment, application data exchange; determining when no application on the user equipment is expected to exchange data; and initiating, from the user equipment, a transition to a less battery demanding radio resource control state or mode.

12 Claims, 8 Drawing Sheets



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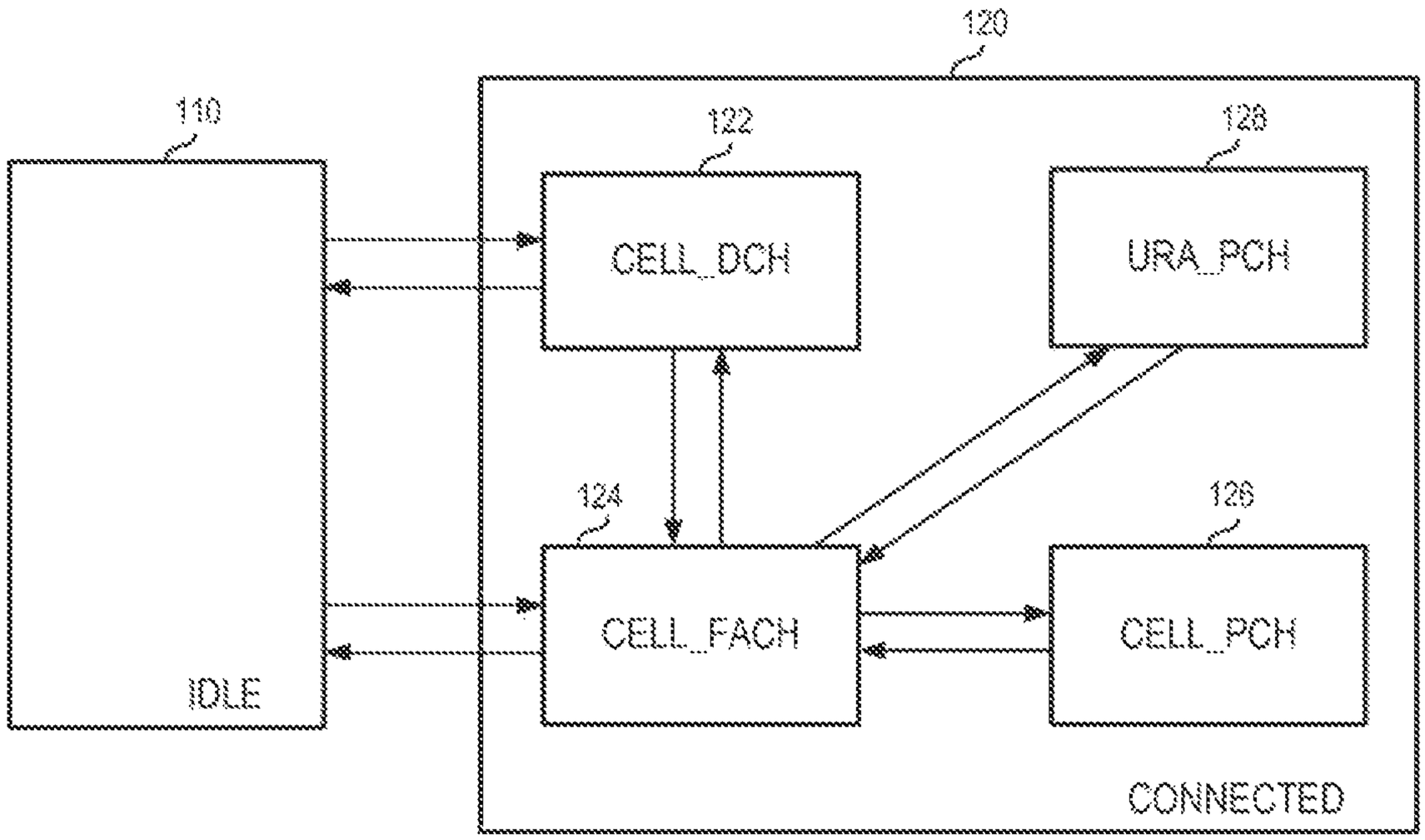

FIG. 1

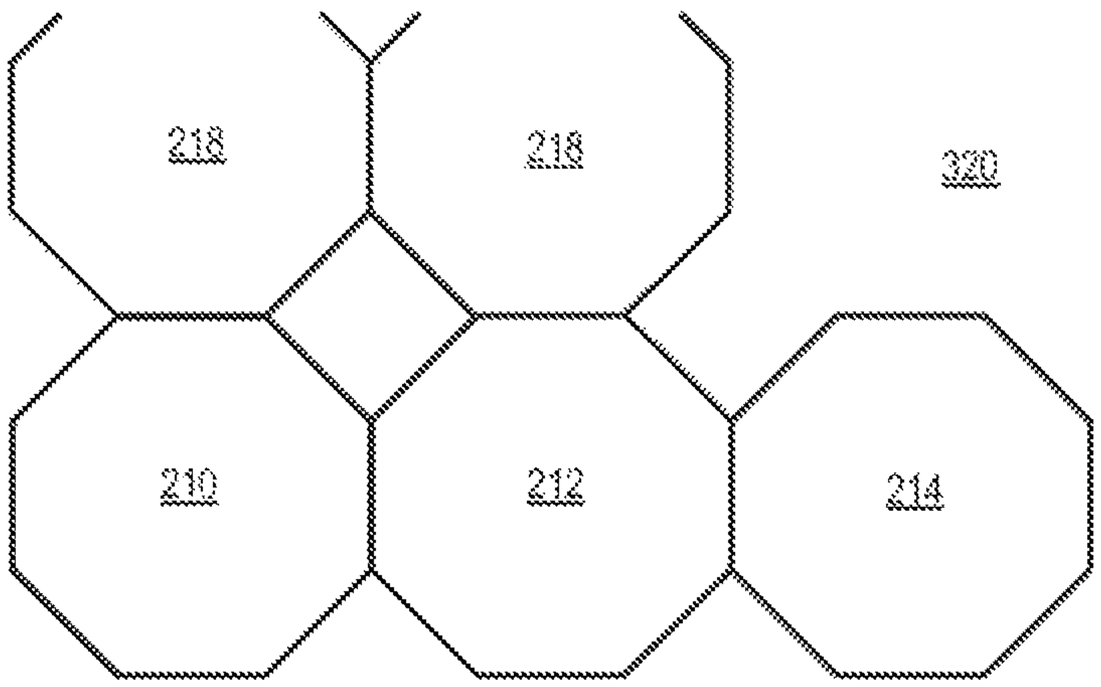

FIG. 2

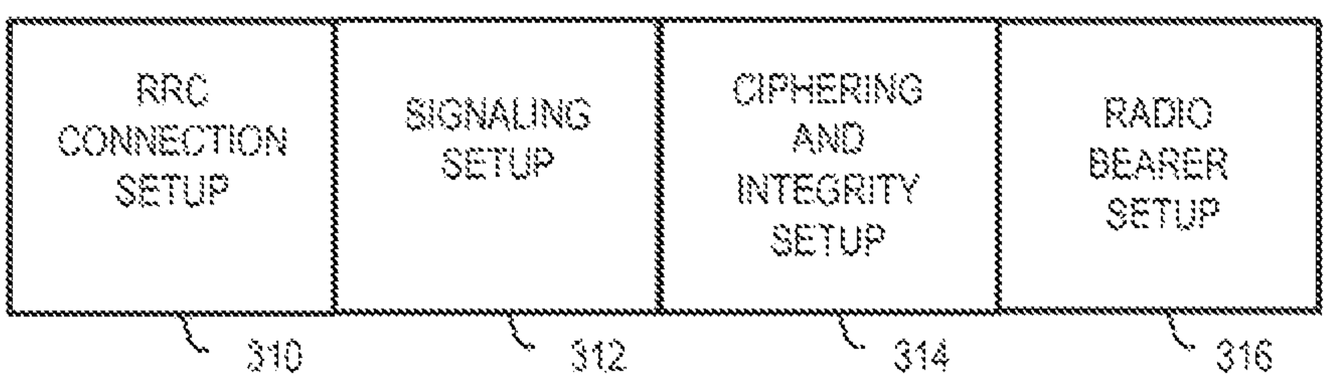

FIG. 3

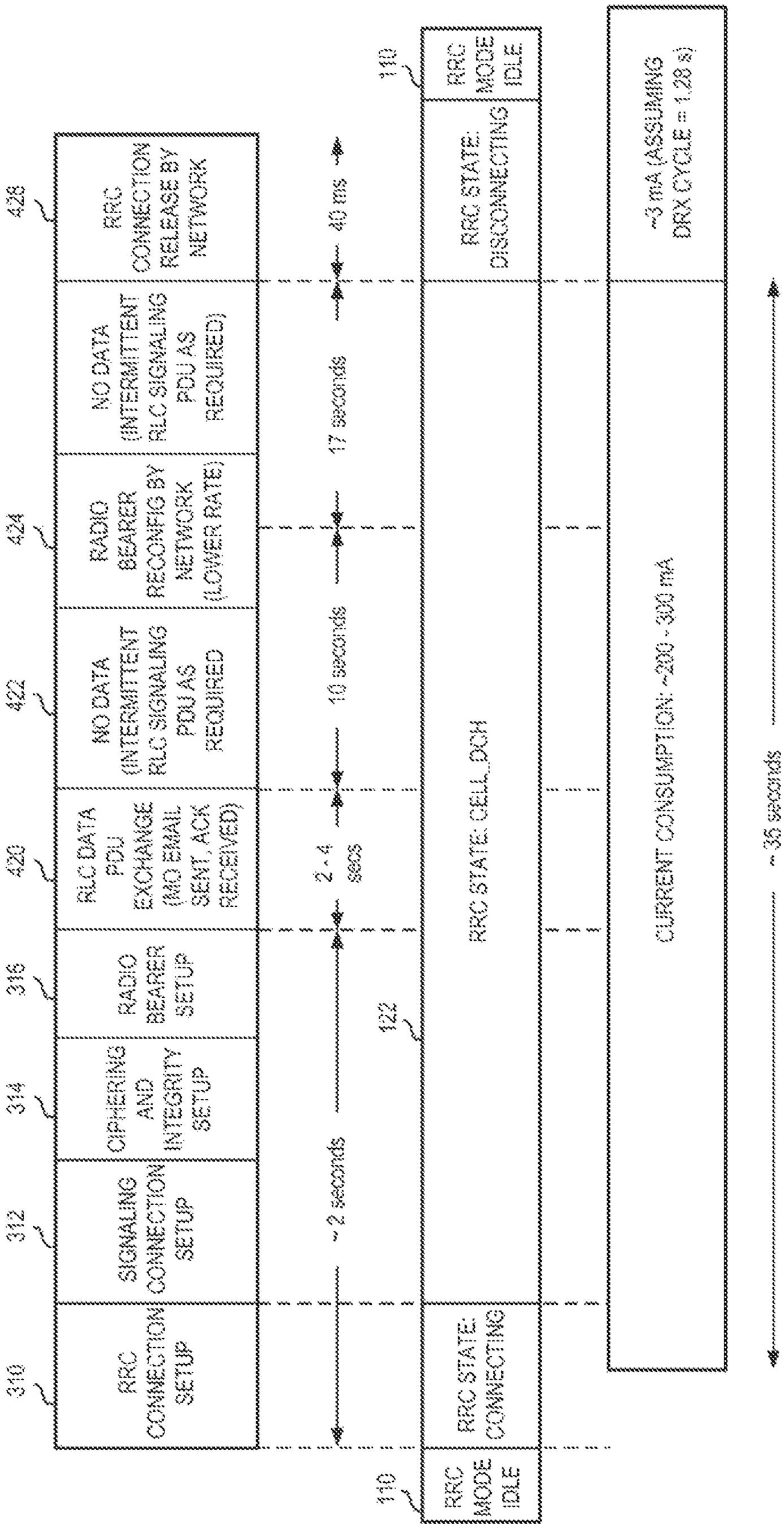
310
RRC CONNECTION SETUP
312
SIGNALING CONNECTION SETUP
314
CIPHERING AND INTEGRITY SETUP
316
RADIO BEARER SETUP
420
RLC DATA PDU EXCHANGE (MO EMAIL SENT, ACK RECEIVED)
422
NO DATA (INTERMITTENT RLC SIGNALING PDU AS REQUIRED
424
RADIO BEARER RECONFIG BY NETWORK (LOWER RATE)
428
RRC CONNECTION RELEASE BY NETWORK
NO DATA (INTERMITTENT RLC SIGNALING PDU AS REQUIRED)
~2 seconds
2 - 4 secs
10 seconds
17 seconds
40 ms
110
RRC MODE IDLE
RRC STATE: CELL_DCH
RRC STATE: CONNECTING
RRC STATE: DISCONNECTING
RRC MODE IDLE
122
CURRENT CONSUMPTION: ~200 - 300 mA
~3 mA (ASSUMING DRX CYCLE = 1.28 s)
~36 seconds

FIG. 4A

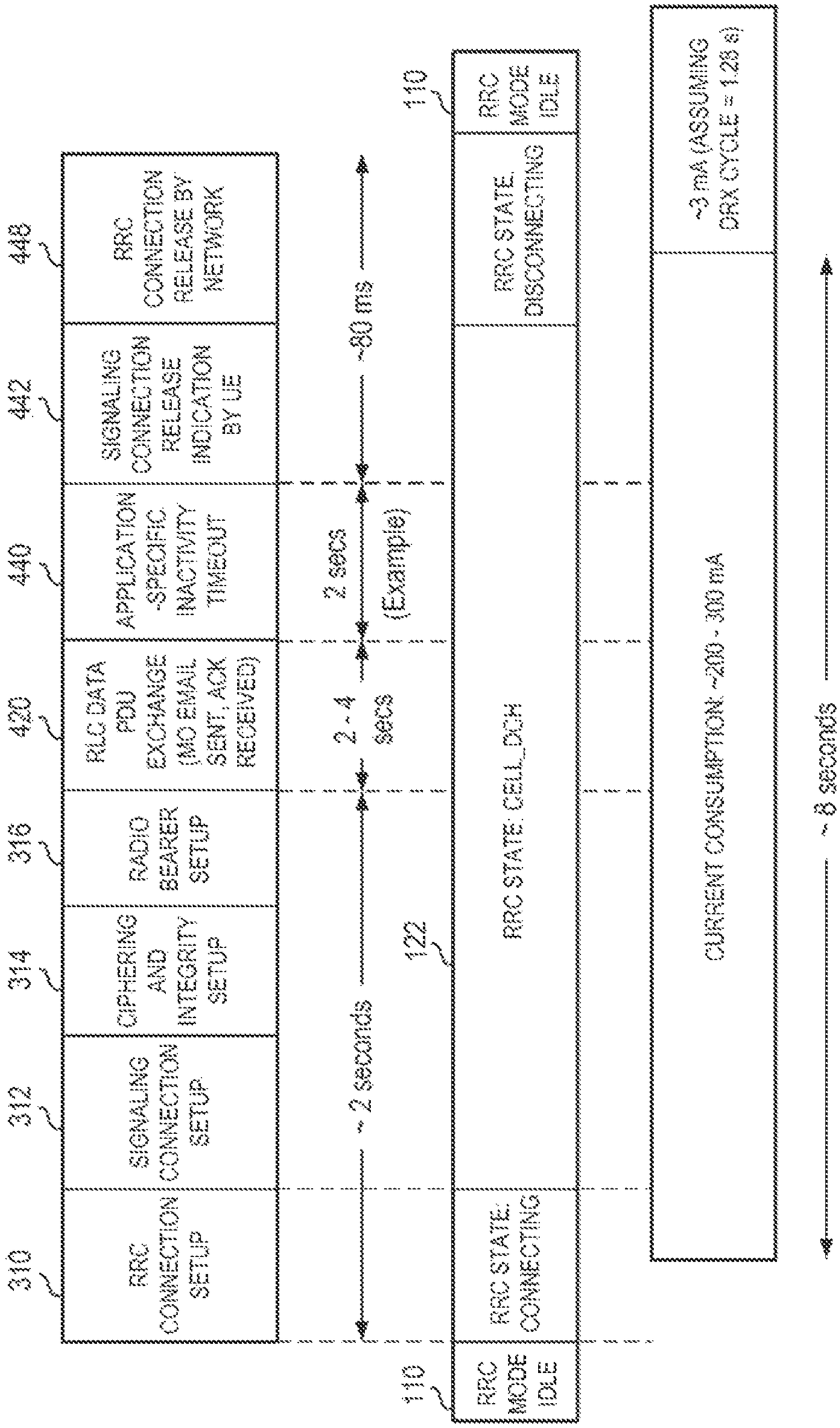
448
RRC CONNECTION RELEASE BY NETWORK
314
CIPHERING AND INTEGRITY SETUP
316
RADIO BEARER SETUP
420
RLC DATA PDU EXCHANGE (MO EMAIL SENT, ACK RECEIVED)
440
APPLICATION -SPECIFIC INACTIVITY TIMEOUT
442
SIGNALING CONNECTION RELEASE INDICATION BY UE
~80 ms
2 secs
(Example)
2 - 4 secs
122
RRC STATE: CELL_DCH
~3 mA (ASSUMING DRX CYCLE = 1.28 s)
CURRENT CONSUMPTION: ~200 - 300 mA
~ 8 seconds
~ 2 seconds
312
SIGNALING CONNECTION SETUP
310
RRC CONNECTION SETUP
110
RRC MODE IDLE
RRC STATE: CONNECTING
RRC STATE: DISCONNECTING
RRC MODE IDLE

FIG. 4B

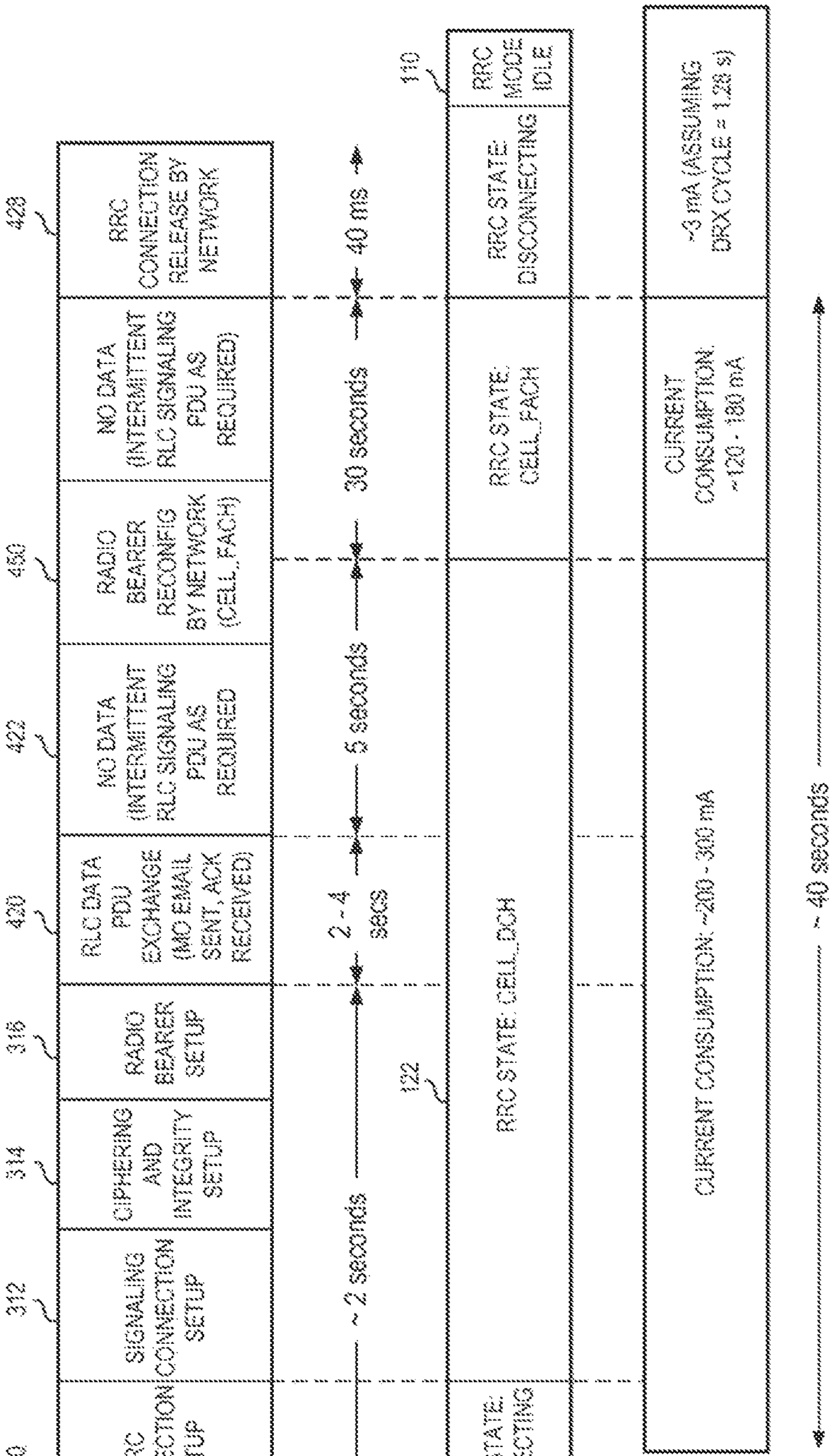
310
312
314
316
420
422
450
428
RRC CONNECTION SETUP
SIGNALING CONNECTION SETUP
CIPHERING AND INTEGRITY SETUP
RADIO BEARER SETUP
RLC DATA PDU EXCHANGE (MO EMAIL SENT, ACK RECEIVED)
NO DATA (INTERMITTENT RLC SIGNALING PDU AS REQUIRED
RADIO BEARER RECONFIG BY METWORK (CELL_FACH)
RRC CONNECTION RELEASE BY NETWORK
~ 2 seconds
2 ~ 4 secs
5 seconds
30 seconds
40 ms
110
122
RRC MODE IDLE
RRC STATE: CONNECTING
RRC STATE: CELL_DCH
RRC STATE: CELL_FACH
RRC STATE: DISCONNECTING
RRC MODE IDLE
CURRENT CONSUMPTION ~200 - 300 mA
CURRENT CONSUMPTION ~120 - 180 mA
~3 mA (ASSUMING DRX CYCLE = 1.28 s)
~ 40 seconds

FIG. 5A

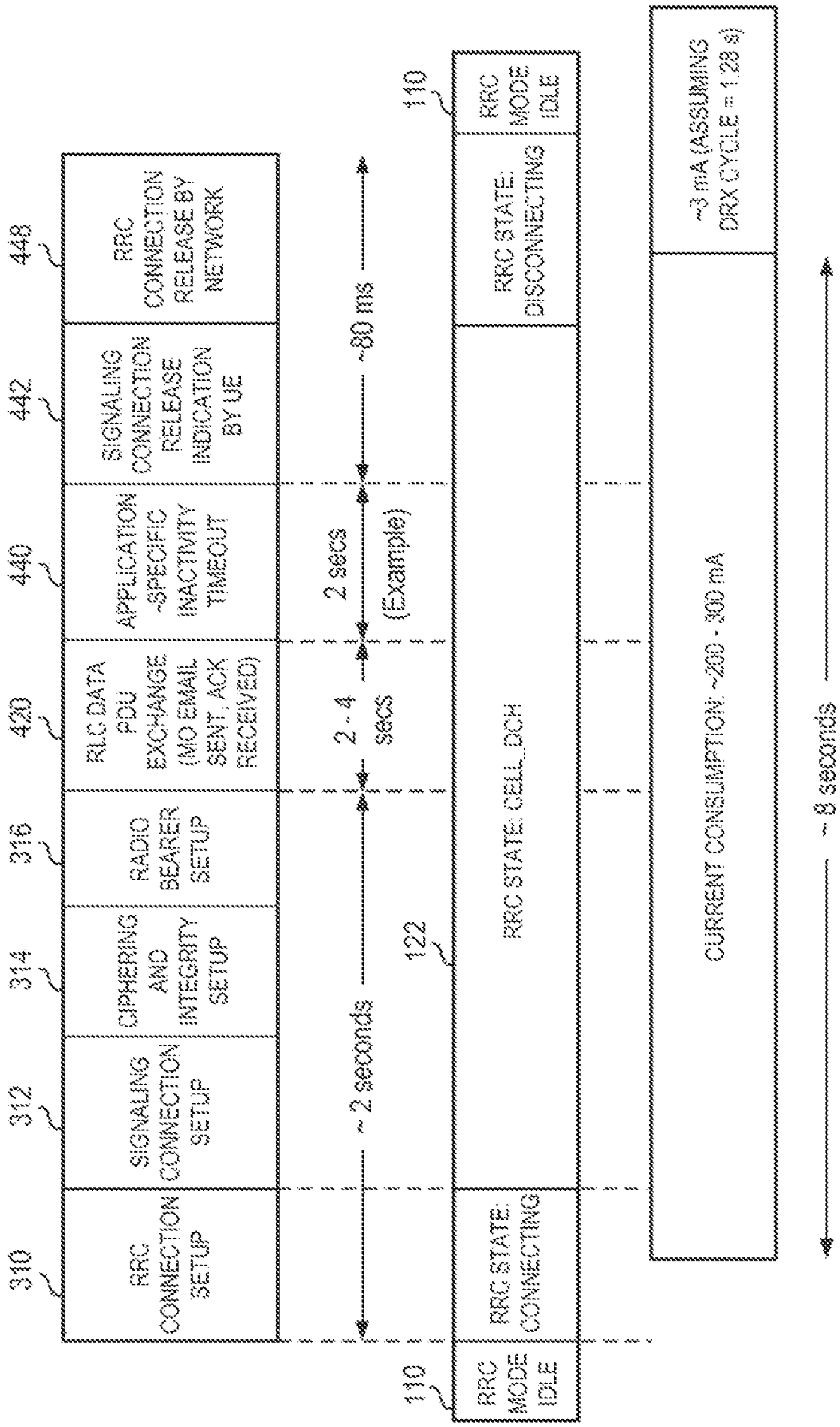
448
RRC CONNECTION RELEASE BY NETWORK
314
CIPHERING AND INTEGRITY SETUP
318
RADIO BEARER SETUP
420
RLC DATA PDU EXCHANGE (MO EMAIL SENT, ACK RECEIVED)
440
APPLICATION -SPECIFIC INACTIVITY TIMEOUT
442
SIGNALING CONNECTION RELEASE INDICATION BY UE
110
RRC MODE IDLE
RRC STATE: DISCONNECTING
~3 mA (ASSUMING DRX CYCLE = 1.28 s)
~80 ms
2 secs
(Example)
2 - 4 secs
122
RRC STATE: CELL_DCH
DI
CURRENT CONSUMPTION: ~200 - 300 mA
~ 8 seconds
~ 2 seconds
312
SIGNALING CONNECTION SETUP
310
RRC CONNECTION SETUP
RRC STATE: CONNECTING
110
RRC MODE IDLE

FIG. 5B

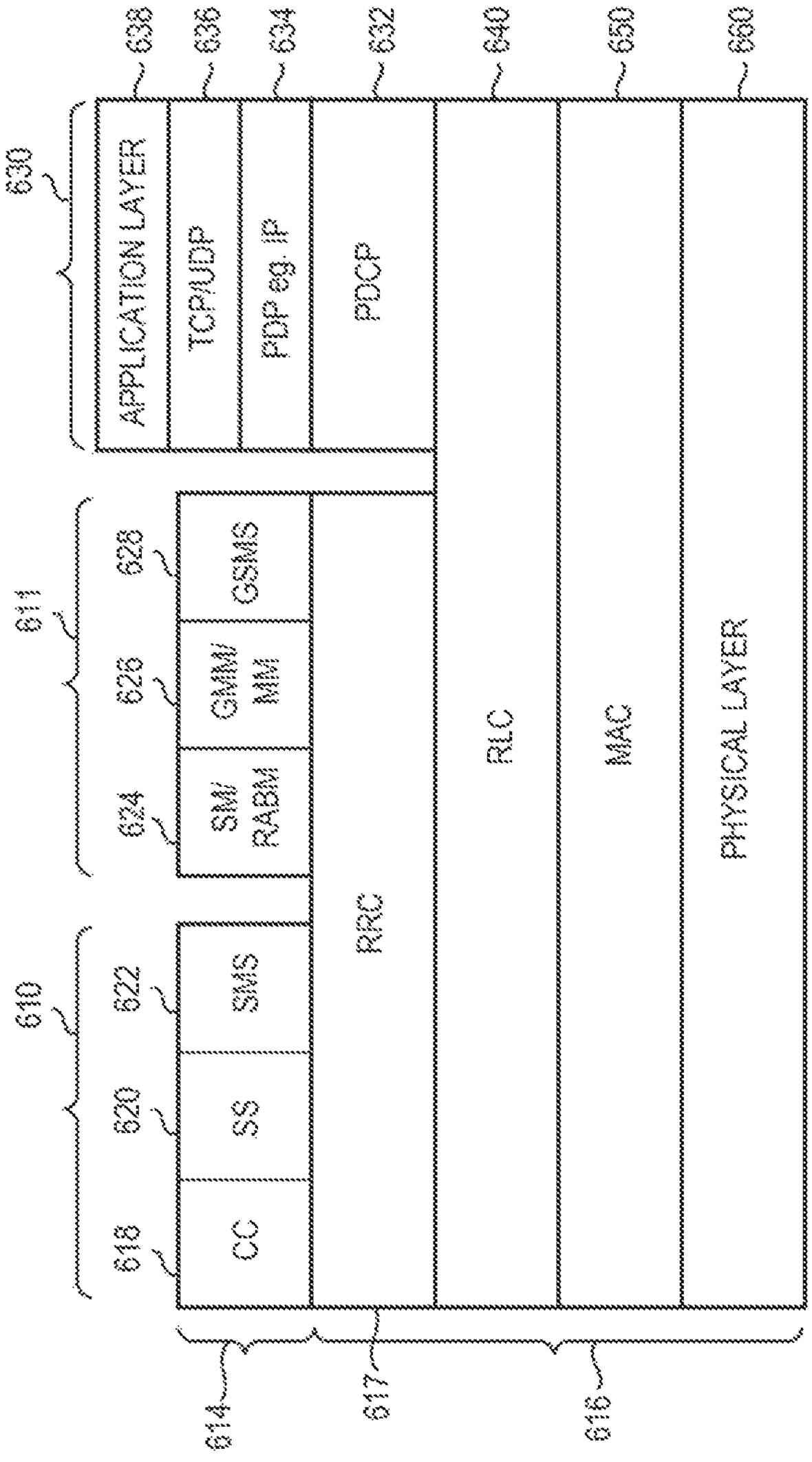
638
636
634
632
640
650
660
630
APPLICATION LAYER
TCP/UDP
PDP eg. IP
PDCP
611
624
626
628
SM/ RABM
GMM/ MM
GSMS
610
622
SMS
RRC
620
SS
618
CC
RLC
MAC
PHYSICAL LAYER
614
617
616

FIG. 6

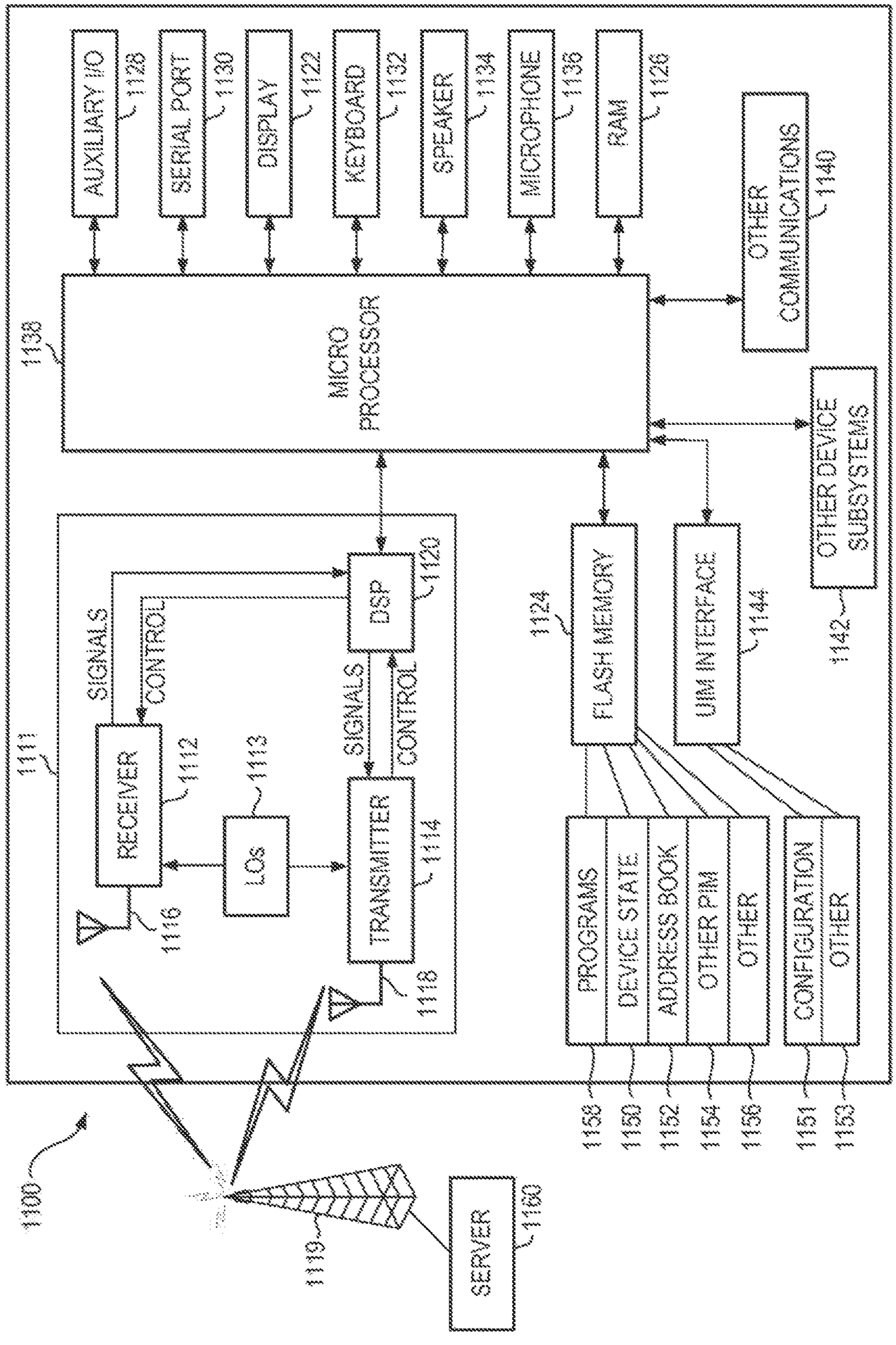
AUXILIARY I/O
1128
SERIAL PORT
1130
DISPLAY
1122
KEYBOARD
1132
SPEAKER
1134
MICROPHONE
1136
RAM
1126
OTHER COMMUNICATIONS
1140
MICRO PROCESSOR
1138
1111
SIGNALS
CONTROL
RECEIVER
1112
1116
LOs
1113
SIGNALS
CONTROL
DSP
1120
TRANSMITTER
1114
1118
1124
FLASH MEMORY
UIM INTERFACE
1144
OTHER DEVICE SUBSYSTEMS
1142
PROGRAMS
DEVICE STATE
ADDRESS BOOK
OTHER PIM
OTHER
CONFIGURATION
OTHER
1158
1160
1152
1154
1156
1151
1153
1100
1119
SERVER
1160

FIG. 7

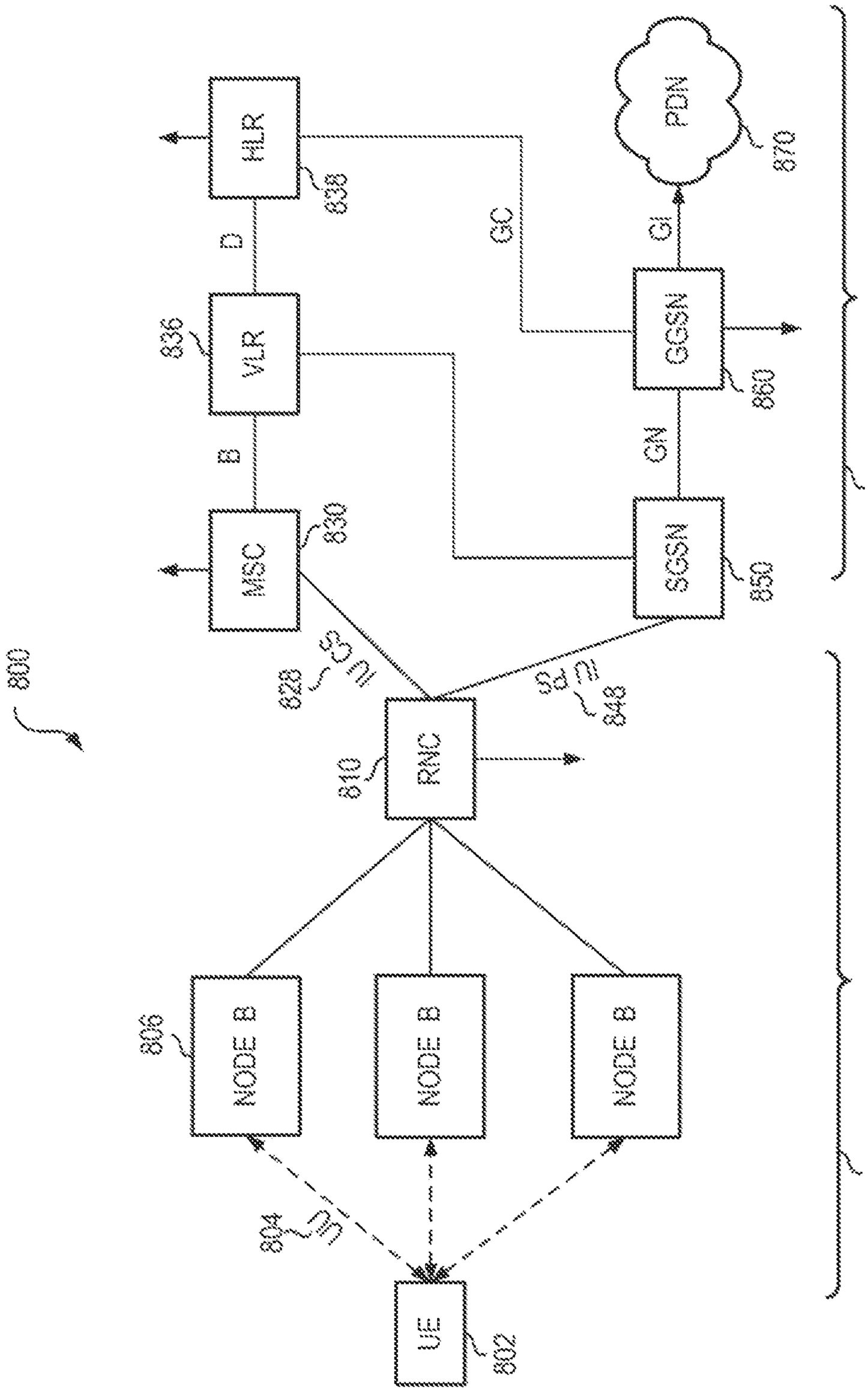
800
UE
802
NODE B
806
NODE B
NODE B
804
3G
RNC
810
828
Iu-CS
848
Iu-PS
MSC
830
SGSN
850
B
Gn
VLR
836
GGSN
860
Gi
PDN
870
HLR
838
D
Gc
821
820

FIG. 8

METHOD AND APPARATUS FOR USER EQUIPMENT DIRECTED RADIO RESOURCE CONTROL IN A UMTS NETWORK

FIELD OF THE APPLICATION

The present application relates to radio resource control between User Equipment (UE) and Universal Terrestrial Radio Access Network (UTRAN), and in particular to the transitioning between modes and states in a UMTS network.

BACKGROUND

A Universal Mobile Telecommunication System (UMTS) is a broadband, packet based system for the transmission of text, digitized voice, video and multi-media. It is a highly subscribed to standard for third generation and is generally based on Wideband Coded Division Multiple Access (W-CDMA).

In a UMTS network, a Radio Resource Control (RRC) part of the protocol stack is responsible for the assignment, configuration and release of radio resources between the UE and the UTRAN. This RRC protocol is described in detail in the 3GPP TS 25.331 specifications. Two basic modes that the UE can be in are defined as "idle mode" and "UTRA connected mode". UTRA stands for UMTS Terrestrial Radio Access. In idle mode, the UE is required to request a RRC connection whenever it wants to send any user data or in response to a page whenever the UTRAN or the Serving GPRS Support Node (SGSN) pages it to receive data from an external data network such as a push server. Idle and Connected mode behaviors are described in details in 3GPP specifications TS 25.304 and TS 25.331.

When in a UTRA RRC connected mode, the device can be in one of four states. These are:

- CELL-DCH: A dedicated channel is allocated to the UE in uplink and downlink in this state to exchange data. The UE must perform actions as outlined in 3GPP 25.331.
- CELL_FACH: no dedicated channel is allocated to the user equipment in this state. Instead, common channels are used to exchange a small amount of bursty data. The UE must perform actions as outlined in 3GPP 25.331 which includes the cell selection process as defined in 3GPP TS 25.304.
- CELL_PCH: the UE uses Discontinuous Reception (DRX) to monitor broadcast messages and pages via a Paging Indicator Channel (PICH). No uplink activity is possible. The UE must perform actions as outlined in 3GPP 25.331 which includes the cell selection process as defined in 3GPP TS 25.304. The UE must perform the CELL UPDATE procedure after cell reselection.
- URA_PCH: the UE uses Discontinuous Reception (DRX) to monitor broadcast messages and pages via a Paging Indicator Channel (PICH). No uplink activity is possible. The UE must perform actions as outlined in 3GPP 25.331 including the cell selection process as defined in 3GPP TS 25.304. This state is similar to CELL_PCH, except that URA UPDATE procedure is only triggered via UTRAN Registration Area (URA) reselection.

The transition from an idle to the connected mode and vise-versa is controlled by the UTRAN. When an idle mode UE requests an RRC connection, the network decides whether to move the UE to the CELL_DCH or CELL_FACH state. When the UE is in an RRC connected mode, again it is the network that decides when to release the

RRC connection. The network may also move the UE from one RRC state to another prior to releasing the connection. The state transitions are typically triggered by data activity or inactivity between the UE and network. Since the network may not know when the UE has completed data exchange, it typically keeps the RRC connection for some time in anticipation of more data to/from the UE. This is typically done to reduce the latency of call set-up and radio bearer setup. The RRC connection release message can only be sent by the UTRAN. This message releases the signal link connection and all radio bearers between the UE and the UTRAN.

The problem with the above is that even if an application on the UE has completed it data transaction and is not expecting to any further data exchange, it still waits for the network to move it to the correct state. The network may not be even aware of the fact that the application on the UE has completed its data exchange. For example, an application on the UE may use its own acknowledgement-based protocol to exchange data with its application server which is connected to the UMTS core network. Examples are applications that run over UDP/IP implementing their own guaranteed delivery. In such a case, the UE knows whether the application server has sent or received all the data packets or not and is in a better position to determine if any further data exchange is to take place and hence decide when to terminate the RRC connection. Since the UTRAN controls when the RRC connected state is changed to a different, less battery intensive state or into an idle mode, and the fact that UTRAN is not aware of the status of data delivery between the UE and external server, the UE is forced to stay in a higher data rate and intensive battery state than the required state or mode, thereby draining battery life and wasting network resources.

BRIEF DESCRIPTION OF THE DRAWINGS

The present application will be better understood with reference to the drawings in which:

FIG. **1** is a block diagram showing RRC states and transitions;

FIG. **2** is a schematic of a UMTS network showing various UMTS cells and a URA;

FIG. **3** is a block diagram showing the various stages in an RRC connection setup;

FIG. **4**A is a block diagram of an exemplary transition between a CELL_DCH connected mode state and an idle mode initiated by the UTRAN according to current method;

FIG. **4**B is a block diagram showing an exemplary transition between a CELL_DCH state connected mode transition to an idle mode according to the present method and apparatus;

FIG. **5**A is a block diagram of an exemplary transition between a CELL_DCH inactivity to a CELL_FACH inactivity to an idle mode initiated by the UTRAN according to current method;

FIG. **5**B is a block diagram of an exemplary transition between CELL_DCH inactivity and an idle mode according to the present method;

FIG. **6** is a block diagram of a UMTS protocol stack;

FIG. **7** is an exemplary UE that can be used in association with the present method; and

FIG. **8** is an exemplary network for use in association with the present method and apparatus.

DETAILED DESCRIPTION

The present system and method overcome the deficiencies of the prior art by providing for the transitioning from an

RRC connected mode to a more battery efficient state or mode. In particular, the present method and apparatus provide for transitioning based on either the UE initiating termination of a signaling connection for a specified core network domain or indicating to the UTRAN that a transition should occur from one connected state to another.

In particular, if an application on the UE determines that it is done with the exchange of data, it can send a "done" indication to the "RRC connection manager" component of UE software. The RRC connection manager keeps track of all existing applications (including those providing a service over one or multiple protocols), associated Packet Data Protocol (PDP) contexts, associated packet switched (PS) radio bearers and associated circuit switched (CS) radio bearers. A PDP Context is a logical association between a UE and PDN (Public Data Network) running across a UMTS core network. One or multiple applications (e.g. an e-mail application and a browser application) on the UE may be associated with one PDP context. In some cases, one application on the UE is associated with one primary PDP context and multiple applications may be tied with secondary PDP contexts. The RRC Connection Manager receives "done" indications from different applications on the UE that are simultaneously active. For example, user may receive an e-mail from a push server while browsing the web. After the e-mail application has sent an acknowledgment, it may indicate that it has completed its data transaction, however, the browser application may not send such indication. Based on a composite status of such indications from active applications, UE software can decide how long it should wait before it can initiate a signaling connection release of the core network packet service domain. A delay in this case can be introduced to ensure that the application is truly finished with data exchange and does not require an RRC connection. The delay can be dynamic based on traffic history and/or application profiles. Whenever the RRC connection manager determines that with some probability that no application is expected to exchange any data, it can send a signaling connection release indication procedure for the appropriate domain (e.g. PS domain). Alternatively it can send a request for state transition within connected mode to the UTRAN.

The above decision may also take into account whether network supports URA_PCH state and the transition behaviour to this state.

The UE initiated transition to idle mode can happen from any state of the RRC connected mode and ends up having the network release the RRC connection and moving to idle mode. The UE being in idle mode, as will be appreciated by those skilled in the art, is much less battery intensive than the UE being in a connected state.

The present application therefore provides a method for improved battery performance of user equipment in a wireless network having multiple radio resource control (RRC) states, comprising the steps of: monitoring, at the user equipment, application data exchange; determining when no application on the user equipment is expected to exchange data; and initiating, from the user equipment, a transition to a less battery demanding radio resource control state or mode.

The present application further provides user equipment adapted for reduces battery consumption in a UMTS network, the user equipment having a radio subsystem including a radio adapted to communicate with the UMTS network; a radio processor having a digital signal processor and adapted to interact with said radio subsystem; memory; a user interface; a processor adapted to run user applications and interact with the memory, the radio and the user interface and adapted to run applications, the user equipment characterized by having means for: monitoring, at the user equipment, application data exchange; determining when no application on the user equipment is expected to exchange data; and initiating, from the user equipment, a transition to a less battery demanding radio resource control state or mode.

Reference is now made to FIG. **1**. FIG. **1** is a block diagram showing the various modes and states for the radio resource control portion of a protocol stack in a UMTS network. In particular, the RRC can be either in an RRC idle state **110** or an RRC connected state **120**.

As will be appreciated by those skilled in the art, a UMTS network consists of two land-based network segments. These are the Core Network (CN) and the Universal Terrestrial Radio-Access Network (UTRAN) (as illustrated in FIG. **8**). The Core Network is responsible for the switching and routing of data calls and data connections to the external networks while the UTRAN handles all radio related functionalities.

In idle mode **110**, the UE must request an RRC connection to set up the radio resource whenever data needs to be exchanged between the UE and the network. This can be as a result of either an application on the UE requiring a connection to send data, or as a result of the UE monitoring a paging channel to indicate whether the UTRAN or SGSN has paged the UE to receive data from an external data network such as a push server. In addition, UE also requests RRC connection whenever it needs to send Mobility Management signaling message such as Location Area Update.

Once the UE has sent a request to the UTRAN to establish a radio connection, the UTRAN chooses a state for the RRC connection to be in. Specifically, the RRC connected mode **120** includes four separate states. These are CELL_DCH state **122**, CELL_FACH state **124**, CELL_PCH state **126** and URA_PCH state **128**.

From idle mode **110** the RRC connected state can either go to the Cell Dedicated Channel (CELL_DCH) state **122** or the Cell Forward Access Channel (CELL_FACH) state **124**.

In CELL_DCH state **122**, a dedicated channel is allocated to the UE for both uplink and downlink to exchange data. This state, since it has a dedicated physical channel allocated to the UE, typically requires the most battery power from the UE.

Alternatively, the UTRAN can move from idle mode **110** to a CELL_FACH state **124**. In a CELL_FACH state no dedicated channel is allocated to the UE. Instead, common channels are used to send signaling in a small amount of bursty data. However, the UE still has to continuously monitor the FACH, and therefore it consumes battery power.

Within the RRC connected mode **120**, the RRC state can be changed at the discretion of the UTRAN. Specifically, if data inactivity is detected for a specific amount of time or data throughput below a certain threshold is detected, the UTRAN may move the RRC state from CELL_DCH state **122** to the CELL_FACH state **124**, CELL_PCH state **126** or URA_PCH state **128**. Similarly, if the payload is detected to be above a certain threshold then the RRC state can be moved from CELL_FACH **124** to CELL_DCH **122**.

From CELL_FACH state **124**, if data inactivity is detected for predetermined time in some networks, the UTRAN can move the RRC state from CELL_FACH state **124** to a paging channel (PCH) state. This can be either the CELL_PCH state **126** or URA_PCH state **128**.

From CELL_PCH state **126** or URA_PCH state **128** the UE must move to CELL_FACH state **124** in order to initiate

an update procedure to request a dedicated channel. This is the only state transition that the UE controls.

CELL_PCH state **126** and URA_PCH state **128** use a discontinuous reception cycle (DRX) to monitor broadcast messages and pages by a Paging Indicator Channel (PICH). No uplink activity is possible.

The difference between CELL_PCH state **126** and URA_PCH state **128** is that the URA_PCH state only triggers a URA Update procedure if the UEs current UTRAN registration area (URA) is not among the list of URA identities present in the current cell. Specifically, reference is made to FIG. **2**. FIG. **2** shows an illustration of various UMTS cells **210**, **212** and **214**. All of these cells require a cell update procedure if reselected to a CELL_PCH state. However, in a UTRAN registration area, each will be within the same UTRAN registration area **220**, and thus a URA update procedure is not triggered when moving between **210**, **212** and **214** when in a URA_PCH mode.

As seen in FIG. **2**, other cells **218** are outside the URA **220**, and can be part of a separate URA or no URA.

As will be appreciated by those skilled in the art, from a battery life perspective the idle state provides the lowest battery usage compared with the states above. Specifically, because the UE is required to monitor the paging channel only at intervals, the radio does not need to continuously be on, but will instead wake up periodically. The trade-off for this is the latency to send data. However, if this latency is not too great, the advantages of being in the idle mode and saving battery power outweigh the disadvantages of the connection latency.

Reference is again made to FIG. **1**. Various UMTS infrastructure vendors move between states **122**, **124**, **126** and **128** based on various criteria. Exemplary infrastructures are outlined below.

In a first exemplary infrastructure, the RRC moves between an idle mode and a Cell_DCH state directly. In the Cell_DCH state, if two seconds of inactivity are detected, the RRC state changes to a Cell_FACH state **124**. If in Cell_FACH state **124**, ten seconds of inactivity are detected then the RRC state changes to PCH state **126**. Forty five minutes of inactivity in Cell_PCH states **126** will result in the RRC state moving back to idle mode **110**.

In a second exemplary infrastructure, RRC transition can occur between an idle mode **110** and connected mode **120** depending on a payload threshold. In the second infrastructure, if the payload is below a certain threshold then the UTRAN moves the RRC state to CELL_FACH state **124**. Conversely, if the data is above a certain payload threshold then the UTRAN moves the RRC state a CELL_DCH state **122**. In the second infrastructure, if two minutes of inactivity are detected in CELL_DCH state **122**, the UTRAN moves the RRC state to CELL_FACH state **124**. After five minutes of inactivity in the CELL-FACH state **124**, the UTRAN moves the RRC stage to CELL_PCH state **126**. In CELL_PCH state **126**, two hours of inactivity are required before moving back to idle mode **110**.

In a third exemplary infrastructure, movement between idle mode and connected mode **120** is always to CELL_DCH state **122**. After five seconds of inactivity in CELL_DCH state **122** the UTRAN moves the RRC state to CELL_FACH state **124**. Thirty seconds of inactivity in CELL_FACH state **124** results in the movement back to idle mode **110**.

In a fourth exemplary infrastructure the RRC transitions from an idle mode to a connected mode directly into a CELL_DCH state **122**. In the fourth exemplary infrastructure, CELL_DCH state **122** includes two sub-states. The first includes a sub-state which has a high data rate and a second sub-state includes a lower data rate, but still within the CELL_DCH state. In the fourth exemplary infrastructure, the RRC transitions from idle mode **110** directly into the high data rate CELL_DCH sub-state. After 10 seconds of inactivity the RRC state transitions to a low data rate CELL_DCH state. Seventeen seconds of inactivity from the low data CELL_DCH state **122** result in the RRC state changing it to idle mode **110**.

The above four exemplary infrastructure shows how various UMTS infrastructure vendors are implementing the states. As will be appreciated by those skilled in the art, in each case, if the time spent on exchanging actual data (such as an email) is significantly short compared to the time that is required to stay in the CELL_DCH or the CELL_FACH states, this causes unnecessary current drain which makes user experience in newer generation networks such as UMTS worse than in prior generation networks such as GPRS.

Further, although the CELL_PCH state is more optimal than the CELL_FACH state from a battery life perspective, the DRX cycle in a CELL_PCH state is typically set to a lower value than the idle mode **110**. As a result, the UE is required to wake up more frequently in the CELL_PCH state than in an idle mode.

The URA_PCH state with a DRX cycle similar to that of the idle state is likely the optimal trade up between battery life and latency for connection. However, URA_PCH is currently not supported in the UTRAN. It is therefore desirable to quickly transition to the idle mode as quickly as possible after an application is finished with the data exchange from a battery life perspective.

Reference is now made to FIG. **3**. When transitioning from an idle mode to a connected mode various signaling and data connections need to be made. Referring to FIG. **3**, the first item needing to be performed is an RRC connection set-up. As indicated above, this RRC connection setup can only be torn down by the UTRAN.

Once RRC connection setup **310** is accomplished, a signaling connection setup **312** is started.

Once signaling setup **312** is finished, a ciphering and integrity setup **314** is started. Upon completion of this, a radio bearer setup **316** is accomplished. At this point, data can be exchanged between the UE and UTRAN.

Tearing down a connection is similarly accomplished in the reverse order, in general. The radio bearer setup **316** is taken down and then the RRC connection setup **310** is taken down. At this point, the RRC moves into idle mode **110** as illustrated in FIG. **1**.

Although the current 3GPP specification does not allow the UE to release the RRC connection or indicate its preference for RRC state, the UE can still indicate termination of a signaling connection for a specified core network domain such as the Packet Switched (PS) domain used by packet-switched applications. According to section 8.1.14.1 of 3GPP TS 25.331;

> The signaling connection release indication procedure is used by the UE to indicate to the UTRAN that one of its signaling connection has been released. This procedure may in turn initiate the RRC connection release procedure.

Thus staying within the current 3GPP specifications, signaling connection release may be initiated upon the tearing down of the signaling connection setup **312**. It is within the ability of the UE to tear down signaling connection setup **312**, and this in turn according to the specification "may" initiate the RRC connection release.

As will be appreciated by those skilled in the art, if signaling connection setup **312** is torn down, the UTRAN will also need to clean up deciphering and integrity setup **312** radio bearer setup **316** after the signaling connection setup **312** has been torn down.

If signaling connections setup **312** is torn down, the RRC connection setup is typically brought down by the network for current vendor infrastructures.

Using the above, if the UE determines that it is done with the exchange of data, for example if a "RRC connection manager" component of the UE software is provided with an indication that the exchange of data is complete, then the RRC connection manager may determine whether or not to tear down the signaling connection setup **312**. For example, an email application on the device sends an indication that it has received an acknowledgement from the push email server that the email was indeed received by the push server. The RRC manager can keep track of all existing applications, associated PDP contexts, associated PS radio bearers and associated circuit switched (CS) radio bearers. A delay in this case can be introduced to ensure that the application is truly finished with data exchange and no longer requires an RRC connection even after it has sent the "done" indication. This delay is equivalent to inactivity timeout associated with the application. Each application can have its own inactivity timeout. For example, an email application can have an inactivity timeout of five seconds, whereas an active browser application can have a timeout of sixty seconds. Based on a composite status of all such indications from active applications, the UE software decides how long it should wait before it can initiate a signaling connection release of the appropriate core network (e.g. PS Domain).

The inactivity timeout can be made dynamic based on a traffic pattern history and/or application profile.

Whenever the RRC connection manager determines with some probability that no application is expected the exchange of data, it can send a signaling connection release indication procedure for the appropriate domain.

The above UE initiated transition to idle mode can happen in any stage of the RRC connected mode **120** as illustrated in FIG. **1** and ends up having the network release the RRC connection and moving to a idle mode **110** as illustrated in FIG. **1**. This is also applicable when the UE is performing any packet data services during a voice call. In this case only the PS domain is released, but the CS domain remains connected.

As will be appreciated by those skilled in the art, in some cases it may be more desirable to be in the connected mode state URA_PCH than in idle mode. For example, if the latency for connection to the CELL_DCH or the CELL_FACH connected mode states is required to be lower, it is preferable to be in a connected mode PCH state. There are two ways of accomplishing this. First is by changing the 3GPP specifications to allow for the UE to request the UTRAN move it to a specific state, in this case the URA_PCH state **128**.

Alternatively, the RRC connection manager may take into account other factors such as what state the RRC connection is currently in. If, for example, the RRC connection is in the URA_PCH state it may decide that it is unnecessary to move to idle mode **110** and thus no Signaling connection release procedure is initiated.

Reference is made to FIG. **4**. FIG. **4**A shows a current UMTS implementation according to the infrastructure "four" example above. As illustrated in FIG. **4**, time is across the horizontal axes.

The UE starts in RRC idle state **110** and based on local data needing to be transmitted or a page received from the UTRAN, starts to establish an RRC connection.

As illustrated in FIG. **4**A, RRC connection setup **310** occurs first, and the RRC state is a connecting state **410** during this time.

Next, signaling connections setup **312**, ciphering an integrity setup **314**, and radio bearer setup **316** occurs. The RRC state is CELL_DCH state **122** during this. As illustrated in FIG. **4**A, the time for moving from RRC idle to the time that the radio bearer is setup is approximately two seconds in this example.

Data is next exchanged. In the example FIG. **4**A this is achieved in about two to four seconds and is illustrated by step **420**.

After data is exchanged in step **420**, no data is being exchanged except for intermittent RLC signaling PDU as required and thus the radio bearer is reconfigured by the network to move into a lower data rate DCH state after approximately ten seconds. This is illustrated in steps **422** and **424**.

In the lower data rate DCH state nothing is received for seventeen seconds, at which point the RRC connection is released by the network in step **428**.

Once the RRC connection is initiated in step **428**, the RRC state proceeds to a disconnecting state **430** for approximately forty milliseconds, after which the UE is in a RRC idle state **110**.

Also illustrated in FIG. **4**A, the UE current consumption is illustrated for the period in which the RRC is in CELL_DCH state **122**. As seen, the current consumption is approximately 200 to 300 milliamps for the entire duration of the CELL_DCH state. During disconnect and idle, about 3 milliamps are utilized, assuming a DRX cycle of 1.28 seconds. However, the 35 seconds of current consumption at 200 to 300 milliamps is draining on the battery.

Reference is now made to FIG. **4**B. FIG. **4**B utilizes the same exemplary infrastructure "four" from above, only now implementing the signalling connection release

As illustrated in FIG. **4**B, the same setup steps **310**, **312**, **314** and **316** occur and this takes the same amount of time when moving between RRC idle state **110** and RRC CELL_DCH state **122**.

Further, the RRC data PDU exchange for the exemplary email of FIG. **4**A is also done at FIG. **4**B and this takes approximately two to four seconds.

The UE in the example of FIG. **4**B has an application specific inactivity timeout, which in the example of FIG. **4**B is two seconds and is illustrated by step **440**. After the RRC connection manager has determined that there is inactivity for the specific amount of time, the UE releases the signaling connection setup in step **442** and the RRC connection is released by the network in step **428**.

As illustrated in FIG. **4**B, the current consumption during the CELL_DCH step **122** is still about 200 to 300 milliamps. However, the connection time is only about eight seconds. As will appreciated by those skilled in the art, the considerably shorter amount of time that the mobile stays in the cell DCH state **122** results in significant battery savings for an always on UE device.

Reference is now made to FIG. **5**. FIG. **5** shows a second example using the infrastructure indicated above as Infrastructure "three". As with FIGS. **4**A and **4**B, a connection setup occurs which takes approximately two seconds. This requires the RRC connection setup **310**, the signaling connection setup **312**, the ciphering and integrity setup **314** and the radio bearer setup **316**.

During this setup, the UE moves from RRC idle mode **110** to a CELL_DCH state **122** with a RRC state connecting step **410** in between.

As with FIG. **4**A, in FIG. **5**A RLC data PDU exchange occurs, and in the example of FIG. **5**A takes two to four seconds.

According to the infrastructure three, RLC signaling PDU exchange receives no data and thus is idle for period of five seconds in step **422**, except for intermittent RLC signaling PDU as required, at which point the radio bearer reconfigures the network to move into a CELL_FACH state **124** from CELL_DCH state **122**. This is done in step **450**.

In the CELL_FACH state **124**, the RLC signaling PDU exchange finds that there is no data except for intermittent RLC signaling PDU as required for a predetermined amount of time, in this case thirty seconds, at which point a RRC connection release by network is performed in step **428**.

As seen in FIG. **5**A, this moves the RRC state to idle mode **110**.

As further seen in FIG. **5**A, the current consumption during the DCH mode is between 200 and 300 milliamps. When moving into CELL_FACH state **124** the current consumption lowers to approximately 120 to 180 milliamps. After the RRC connector is released and the RRC moves into idle mode **110** the power consumption is approximately 3 milliamps.

The UTRA RRC Connected Mode state being CELL_DCH state **122** or CELL_FACH state **124** lasts for approximately forty seconds in the example of FIG. **5**A.

Reference is now made to FIG. **5**B. FIG. **5**B illustrates the same infrastructure "three" as FIG. **5**A with the same connection time of about two seconds to get the RRC connection setup **310**, signaling connection setup **312**, ciphering integrity setup **314** and radio bearer setup **316**. Further, RLC data PDU exchange **420** take approximately two to four seconds.

As with FIG. **4**B, a UE application detects a specific inactivity timeout in step **440**, at which point the Signalling connection release indication procedure is initiated by the UE and as a consequence the RRC connection is released by the network in step **448**.

As can be seen further in FIG. **5**B, the RRC starts in a idle mode **110**, moves to a CELL_DCH state **122** without proceeding into the CELL_FACH state.

As will be seen further in FIG. **5**B, current consumption is approximately 200 to 300 milliamps in the time that the RRC stage is in CELL_DCH state **122** which according to the example of FIG. **5** is approximate eight seconds.

Therefore, a comparison between FIGS. **4**A and **4**B, and FIGS. **5**A and **5**B shows that a significant amount of current consumption is eliminated, thereby extending the battery life of the UE significantly. As will be appreciated by those skilled in the art, the above can further be used in the context of current 3GPP specs.

Reference is now made to FIG. **6**. FIG. **6** illustrates a protocol stack for a UMTS network.

As seen in FIG. **6**, the UMTS includes a CS control plane **610**, PS control plane **611**, and PS user plane **630**

Within these three planes, a non-access stratum (NAS) portion **614** and an access stratum portion **616** exist.

NAS portion **614** in CS control plane **610** includes a call control (CC) **618**, supplementary services (SS) **620**, and short message service (SMS) **622**.

NAS portion **614** in PS control plane **611** includes both mobility management (MM) and GPRS mobility management (GMM) **626**. It further includes SM/RABM **624** and GSMS **628**.

CC **618** provides for call management signaling for circuit switched services. The session management portion of SM/RABM **624** provides for PDP context activation, deactivation and modification. SM/RABM **624** also provides for quality of service negotiation.

The main function of the RABM portion of the SM/RABM **624** is to connect a PDP context to a Radio Access Bearer. Thus SM/RABM **624** is responsible for the setup, modification and release of radio bearers.

CS control plane **610** and PS control plane **611**, in the access stratum **616** sit on radio resource control (RRC) **617**.

NAS portion **614** in PS user plane **630** includes an application layer **638**, TCP/UDP layer **636**, and PDP layer **634**. PDP layer **634** can, for example, include internet protocol (IP).

Access Stratum **616**, in PS user plane **630** includes packet data convergence protocol (PDCP) **632**. PDCP **632** is designed to make the WCDMA protocol suitable to carry TCP/IP protocol between UE and RNC (as seen in FIG. **8**), and is optionally for IP traffic stream protocol header compression and decompression.

The UMTS Radio Link Control (RLC) **640** and Medium Access Control (MAC) layers **650** form the data link sublayers of the UMTS radio interface and reside on the RNC node and the User Equipment.

The Layer 1 (L1) UMTS layer (physical layer **650**) is below the RLC/MAC layers **640** and **650**. This layer is the physical layer for communications.

While the above can be implemented on a variety of mobile devices, an example of one mobile device is outlined below with respect to FIG. **7**. Reference is now made to FIG. **7**.

UE **1100** is preferably a two-way wireless communication device having at least voice and data communication capabilities. UE **1100** preferably has the capability to communicate with other computer systems on the Internet. Depending on the exact functionality provided, the wireless device may be referred to as a data messaging device, a two-way pager, a wireless e-mail device, a cellular telephone with data messaging capabilities, a wireless Internet appliance, or a data communication device, as examples.

Where UE **1100** is enabled for two-way communication, it will incorporate a communication subsystem **1111**, including both a receiver **1112** and a transmitter **1114**, as well as associated components such as one or more, preferably embedded or internal, antenna elements **1116** and **1118**, local oscillators (LOs) **1113**, and a processing module such as a digital signal processor (DSP) **1120**. As will be apparent to those skilled in the field of communications, the particular design of the communication subsystem **1111** will be dependent upon the communication network in which the device is intended to operate. For example, UE **1100** may include a communication subsystem **1111** designed to operate within the GPRS network or UMTS network.

Network access requirements will also vary depending upon the type of network **1119**. For example, In UMTS and GPRS networks, network access is associated with a subscriber or user of UE **1100**. For example, a GPRS mobile device therefore requires a subscriber identity module (SIM) card in order to operate on a GPRS network. In UMTS a USIM or SIM module is required. In CDMA a RUIM card or module is required. These will be referred to as a UIM interface herein. Without a valid UIM interface, a mobile device may not be fully functional. Local or non-network communication functions, as well as legally required functions (if any) such as emergency calling, may be available, but mobile device **1100** will be unable to carry out any other

functions involving communications over the network **1100**. The UIM interface **1144** is normally similar to a card-slot into which a card can be inserted and ejected like a diskette or PCMCIA card. The UIM card can have approximately 64K of memory and hold many key configuration **1151**, and other information **1153** such as identification, and subscriber related information.

When required network registration or activation procedures have been completed, UE **1100** may send and receive communication signals over the network **1119**. Signals received by antenna **1116** through communication network **1119** are input to receiver **1112**, which may perform such common receiver functions as signal amplification, frequency down conversion, filtering, channel selection and the like, and in the example system shown in FIG. **7**, analog to digital (A/D) conversion. A/D conversion of a received signal allows more complex communication functions such as demodulation and decoding to be performed in the DSP **1120**. In a similar manner, signals to be transmitted are processed, including modulation and encoding for example, by DSP **1120** and input to transmitter **1114** for digital to analog conversion, frequency up conversion, filtering, amplification and transmission over the communication network **1119** via antenna **1118**. DSP **1120** not only processes communication signals, but also provides for receiver and transmitter control. For example, the gains applied to communication signals in receiver **1112** and transmitter **1114** may be adaptively controlled through automatic gain control algorithms implemented in DSP **1120**.

Network **1119** may further communicate with multiple systems, including a server **1160** and other elements (not shown). For example, network **1119** may communicate with both an enterprise system and a web client system in order to accommodate various clients with various service levels.

UE **1100** preferably includes a microprocessor **1138** which controls the overall operation of the device. Communication functions, including at least data communications, are performed through communication subsystem **1111**. Microprocessor **1138** also interacts with further device subsystems such as the display **1122**, flash memory **1124**, random access memory (RAM) **1126**, auxiliary input/output (I/O) subsystems **1128**, serial port **1130**, keyboard **1132**, speaker **1134**, microphone **1136**, a short-range communications subsystem **1140** and any other device subsystems generally designated as **1142**.

Some of the subsystems shown in FIG. **7** perform communication-related functions, whereas other subsystems may provide "resident" or on-device functions. Notably, some subsystems, such as keyboard **1132** and display **1122**, for example, may be used for both communication-related functions, such as entering a text message for transmission over a communication network, and device-resident functions such as a calculator or task list.

Operating system software used by the microprocessor **1138** is preferably stored in a persistent store such as flash memory **1124**, which may instead be a read-only memory (ROM) or similar storage element (not shown). Those skilled in the art will appreciate that the operating system, specific device applications, or parts thereof, may be temporarily loaded into a volatile memory such as RAM **1126**. Received communication signals may also be stored in RAM **1126**. Further, a unique identifier is also preferably stored in read-only memory.

As shown, flash memory **1124** can be segregated into different areas for both computer programs **1158** and program data storage **1150**, **1152**, **1154** and **1156**. These different storage types indicate that each program can allocate a portion of flash memory **1124** for their own data storage requirements. Microprocessor **1138**, in addition to its operating system functions, preferably enables execution of software applications on the mobile device. A predetermined set of applications that control basic operations, including at least data and voice communication applications for example, will normally be installed on UE **1100** during manufacturing. A preferred software application may be a personal information manager (PIM) application having the ability to organize and manage data items relating to the user of the mobile device such as, but not limited to, e-mail, calendar events, voice mails, appointments, and task items. Naturally, one or more memory stores would be available on the mobile device to facilitate storage of PIM data items. Such PIM application would preferably have the ability to send and receive data items, via the wireless network **1119**. In a preferred embodiment, the PIM data items are seamlessly integrated, synchronized and updated, via the wireless network **1119**, with the mobile device user's corresponding data items stored or associated with a host computer system. Further applications may also be loaded onto the mobile device **1100** through the network **1119**, an auxiliary I/O subsystem **1128**, serial port **1130**, short-range communications subsystem **1140** or any other suitable subsystem **1142**, and installed by a user in the RAM **1126** or preferably a non-volatile store (not shown) for execution by the microprocessor **1138**. Such flexibility in application installation increases the functionality of the device and may provide enhanced on-device functions, communication-related functions, or both. For example, secure communication applications may enable electronic commerce functions and other such financial transactions to be performed using the UE **1100**. These applications will however, according to the above, in many cases need to be approved by a carrier.

In a data communication mode, a received signal such as a text message or web page download will be processed by the communication subsystem **1111** and input to the microprocessor **1138**, which preferably further processes the received signal for output to the display **1122**, or alternatively to an auxiliary I/O device **1128**. A user of UE **1100** may also compose data items such as email messages for example, using the keyboard **1132**, which is preferably a complete alphanumeric keyboard or telephone-type keypad, in conjunction with the display **1122** and possibly an auxiliary I/O device **1128**. Such composed items may then be transmitted over a communication network through the communication subsystem **1111**.

For voice communications, overall operation of UE **1100** is similar, except that received signals would preferably be output to a speaker **1134** and signals for transmission would be generated by a microphone **1136**. Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on UE **1100**. Although voice or audio signal output is preferably accomplished primarily through the speaker **1134**, display **1122** may also be used to provide an indication of the identity of a calling party, the duration of a voice call, or other voice call related information for example.

Serial port **1130** in FIG. **7** would normally be implemented in a personal digital assistant (PDA)-type mobile device for which synchronization with a user's desktop computer (not shown) may be desirable. Such a port **1130** would enable a user to set preferences through an external device or software application and would extend the capabilities of mobile device **1100** by providing for information or software downloads to UE **1100** other than through a wireless communication network. The alternate download

path may for example be used to load an encryption key onto the device through a direct and thus reliable and trusted connection to thereby enable secure device communication.

Alternatively, serial port **1130** could be used for other communications, and could include as a universal serial bus (USB) port. An interface is associated with serial port **1130**.

Other communications subsystems **1140**, such as a short-range communications subsystem, is a further optional component which may provide for communication between UE **1100** and different systems or devices, which need not necessarily be similar devices. For example, the subsystem **1140** may include an infrared device and associated circuits and components or a Bluetooth™ communication module to provide for communication with similarly enabled systems and devices.

Reference is now made to FIG. **8**. FIG. **8** is a block diagram of a communication system **800** which, includes a UE **802** which communicates through a wireless communication network.

UE **802** communicates wirelessly with one of multiple Node Bs **806**. Each Node B **806** is responsible for air interface processing and some radio resource management functions. Node B **806** provides functionality similar to a Base Transceiver Station in a GSM/GPRS networks.

The wireless link shown in communication system **800** of FIG. **8** represents one or more different channels, typically different radio frequency (RF) channels, and associated protocols used between the wireless network and UE **802**. A Uu air interface **804** is used between UE **802** and Node B **806**.

An RF channel is a limited resource that must be conserved, typically due to limits in overall bandwidth and a limited battery power of UE **802**. Those skilled in art will appreciate that a wireless network in actual practice may include hundreds of cells depending upon desired overall expanse of network coverage. All pertinent components may be connected by multiple switches and routers (not shown), controlled by multiple network controllers.

Each Node B **806** communicates with a radio network controller (RNC) **810**. The RNC **810** is responsible for control of the radio resources in its area. One RNC **810** control multiple Node Bs **806**.

The RNC **810** in UMTS networks provides functions equivalent to the Base Station Controller (BSC) functions in GSM/GPRS networks. However, an RNC **810** includes more intelligence including, for example, autonomous handovers management without involving MSCs and SGSNs.

The interface used between Node B **806** and RNC **810** is an lub interface **808**. An NBAP (Node B application part) signaling protocol is primarily used, as defined in 3GPP TS 25.433 V3.11.0 (2002-09) and 3GPP TS 25.433 V5.7.0 (2004-01).

Universal Terrestrial Radio Access Network (UTRAN) **820** comprises the RNC **810**, Node B **806** and the Uu air interface **804**.

Circuit switched traffic is routed to Mobile Switching Centre (MSC) **830**. MSC **830** is the computer that places the calls, and takes and receives data from the subscriber or from PSTN (not shown).

Traffic between RNC **810** and MSC **830** uses the Iu-CS interface **828**. Iu-CS interface **828** is the circuit-switched connection for carrying (typically) voice traffic and signaling between UTRAN **820** and the core voice network. The main signaling protocol used is RANAP (Radio Access Network Application Part). The RANAP protocol is used in UMTS signaling between the Core Network **821**, which can be a MSC **830** or SSGN **850** (defined in more detail below) and UTRAN **820**. RANAP protocol is defined in 3GPP TS 25.413 V3.11.1 (2002-09) and TS 25.413 V5.7.0 (2004-01).

For all UEs **802** registered with a network operator, permanent data (such as UE **102** user's profile) as well as temporary data (such as UE's **802** current location) are stored in a home location registry (HLR) **838**. In case of a voice call to UE **802**, HLR **838** is queried to determine the current location of UE **802**. A Visitor Location Register (VLR) **836** of MSC **830** is responsible for a group of location areas and stores the data of those mobile stations that are currently in its area of responsibility. This includes parts of the permanent mobile station data that have been transmitted from HLR **838** to the VLR **836** for faster access. However, the VLR **836** of MSC **830** may also assign and store local data, such as temporary identifications. UE **802** is also authenticated on system access by HLR **838**.

Packet data is routed through Service GPRS Support Node (SGSN) **850**. SGSN **850** is the gateway between the RNC and the core network in a GPRS/UMTS network and is responsible for the delivery of data packets from and to the UEs within its geographical service area. Iu-PS interface **848** is used between the RNC **810** and SGSN **850**, and is the packet-switched connection for carrying (typically) data traffic and signaling between the UTRAN **820** and the core data network. The main signaling protocol used is RANAP (described above).

The SSGN **850** communicates with the Gateway GPRS Support Node (GGSN) **860**. GGSN **860** is the interface between the UMTS/GPRS network and other networks such as the Internet or private networks. GGSN **860** is connected to a public data network PDN **870** over a Gi interface.

Those skilled in art will appreciate that wireless network may be connected to other systems, possibly including other networks, not explicitly shown in FIG. **8**. A network will normally be transmitting at very least some sort of paging and system information on an ongoing basis, even if there is no actual packet data exchanged. Although the network consists of many parts, these parts all work together to result in certain behaviours at the wireless link.

The embodiments described herein are examples of structures, systems or methods having elements corresponding to elements of the techniques of this application. This written description may enable those skilled in the art to make and use embodiments having alternative elements that likewise correspond to the elements of the techniques of this application. The intended scope of the techniques of this application thus includes other structures, systems or methods that do not differ from the techniques of this application as described herein, and further includes other structures, systems or methods with insubstantial differences from the techniques of this application as described herein.

The invention claimed is:

1. A method performed by a node of a wireless network, the method comprising:

receiving, at the node of the wireless network, a message comprising a connection release indication from a user equipment (UE) while the UE is in a first radio resource control (RRC) connected state or mode that is associated with a first discontinuous reception (DRX) cycle, the connection release indication indicating that the UE expects no further data; and

in response to receiving the connection release indication indicating that the UE expects no further data, initiating, by the node of the wireless network and based on the message, a transition of the UE from the first RRC connected state or mode to a second RRC connected state or mode, wherein the second RRC connected state

or mode is more battery efficient than the first RRC connected state or mode, and the second RRC connected state or mode is associated with a second DRX cycle that is longer than the first DRX cycle.

2. The method of claim **1**, wherein the message is an RRC signaling connection release indication (SCM) message.

3. The method of claim **1**, wherein the wireless network is a Universal Mobile Telecommunications System (UMTS) network or a UMTS Terrestrial Radio Access Network (UTRAN).

4. The method of claim **3**, wherein the node is a NodeB or a radio network controller (RNC).

5. A node of a wireless network, the node comprising:

a processor; and

a memory storing instructions which, when executed by the processor, cause the node to perform operations of:

receiving, at the node of the wireless network, a message comprising a connection release indication from a user equipment (UE) while the UE is in a first radio resource control (RRC) connected state or mode that is associated with a first discontinuous reception (DRX) cycle, the connection release indication indicating that the UE expects no further data; and

in response to receiving the connection release indication indicating that the UE expects no further data, initiating, by the node of the wireless network and based on the message, a transition of the UE from the first RRC connected state or mode to a second RRC connected state or mode, wherein the second RRC connected state or mode is more battery efficient than the first RRC connected state or mode, and the second RRC connected state or mode is associated with a second DRX cycle that is longer than the first DRX cycle.

6. The node of claim **5**, wherein the message is an RRC signaling connection release indication (SCM) message.

7. The node of claim **5**, wherein the wireless network is a Universal Mobile Telecommunications System (UMTS) network or a UMTS Terrestrial Radio Access Network (UTRAN).

8. The node of claim **7**, wherein the node is a NodeB or a radio network controller (RNC).

9. A non-transitory computer readable medium storing instructions to cause a processor to perform operations comprising:

receiving, at a node of a wireless network, a message comprising a connection release indication from a user equipment (UE) while the UE is in a first radio resource control (RRC) connected state or mode that is associated with a first discontinuous reception (DRX) cycle, the connection release indication indicating that the UE expects no further data; and

in response to receiving the connection release indication indicating that the UE expects no further data, initiating, by the node of the wireless network and based on the message, a transition of the UE from the first RRC connected state or mode to a second RRC connected state or mode, wherein the second RRC connected state or mode is more battery efficient than the first RRC connected state or mode, and the second RRC connected state or mode is associated with a second DRX cycle that is longer than the first DRX cycle.

10. The computer readable medium of claim **9**, wherein the message is an RRC signaling connection release indication (SCM) message.

11. The computer readable medium of claim **9**, wherein the wireless network is a Universal Mobile Telecommunications System (UMTS) network or a UMTS Terrestrial Radio Access Network (UTRAN).

12. The computer readable medium of claim **11**, wherein the node is a NodeB or a radio network controller (RNC).

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